

Goddard Space Flight Center

Task: Effect of Liquid Penetrant Sensitivity on Probability of Detection

Center Point of Contact:

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Objectives:

The objective of the task is to investigate the effect of liquid penetrant sensitivity level on probability of detection (POD) of cracks in various metals. NASA-STD-5009 currently requires the use of only sensitivity level 4 liquid penetrants for NASA Standard Level inspections. This requirement is based on the fact that the data used to establish the reliably detectable flaw sizes penetrant inspection was from studies performed in the 1970s using penetrant deemed to be equivalent only to modern day sensitivity level 4 penetrants. However, many NDE contractors supporting NASA Centers routinely use sensitivity level 3 penetrants. Because of the new NASA-STD-5009 requirement, these contractors will have to either shift to sensitivity level 4 penetrants or perform formal POD demonstration tests to qualify their existing process.

Technical Methodology/Approach:

We propose a study to compare the POD generated for two penetrant manufactures, Sherwin and Magnaflux, and for the two most common penetrant inspection methods, water washable and post emulsifiable, hydrophilic. NDE vendors local to GSFC will be employed. A total of six inspectors will inspect a set of crack panels with a broad range of fatigue crack sizes. Each inspector will perform eight inspections of the panel set using the combination of methods and sensitivity levels described above. At least one inspector will also perform multiple inspections using a fixed technique to investigate repeatability. The hit/miss data sets will be evaluated using both the NASA generated DOEPOD software and the MIL-STD-1823 software.

Customers:

James Webb Space Telescope (JWST)

Constellation Program

Accomplishments:

A total of 92 POD demonstration tests have been completed. Tests were performed on 6061-Al panels from GSFC, Haynes 188 panels from MSFC and Ti-6Al-4V panels from JSC. Nine different inspectors were involved in the study. Forty six of the demonstration tests involved sensitivity level 3 penetrants and 46 involved sensitivity level 4 penetrants. The results are summarized in the table below.

Benefits/Payoffs:

Eliminating the requirement for all NDE vendors to shift to solely Level 4 penetrants will result in significant cost savings across the Agency.

Status:

The results from the completed demonstration tests are summarized in the table below. These results show that for a controlled process with experienced inspectors, there is very little difference in the performance of sensitivity level 3 versus level 4 penetrants. Based on the overall percentage of cracks found, in three of the six cases (combinations of a particular metal and inspection method), the sensitivity level 3 penetrants performed better than the level 4 penetrants. The detectable crack sizes demonstrated by the sensitivity level 3 penetrants in all cases are well below the NASA Standard Level flaw sizes for penetrant inspections (0.150 inches), which indicates that sensitivity level 3 penetrants are acceptable for NASA Standard Level inspections.

Future Work:

The task is complete. A final report in the form a NASA Technical Memorandum is in the final review process. The requirement in NASA-STD-5009 for use of only sensitivity level 4 penetrants is in the process of being changed.

Additional Information:

Results from the demonstration tests performed on the 6061-Al crack panels can be found in NASA/TM-2009-215850.

Metal	Method	Number of Trials	Sensitivity Level	Percent of Cracks Hit	Logit Curve Fit a90/95 on Combined Data Set (inches)
6061 Al	A	10	3	92.7	0.052
6061 Al	A	10	4	93.0	0.051
Haynes 188	A	6	3	94.7	0.046
Haynes 188	A	6	4	94.5	0.049
Ti-6Al-4V	A	6	3	97.8	0.043
Ti-6Al-4V	A	6	4	96.2	0.044
6061 Al	D	12	3	97.4	0.040
6061 Al	D	12	4	96.1	0.045
Haynes 188	D	6	3	95.6	0.043
Haynes 188	D	6	4	96.7	0.039
Ti-6Al-4V	D	6	3	96.4	0.041
Ti-6Al-4V	D	6	4	97.2	0.042

Table 1: Summary of all demonstration tests performed in the study.